USGS
science for a changing world

Updates from the USGS National Wildlife Health Center

Fall 2021

DC area passerine morbidity-mortality event

In late May 2021, wildlife managers in Washington D.C., Maryland, Virginia, West Virginia, and Kentucky began receiving reports of sick, dying, and dead birds with eye swelling and crusty discharge, some of which also reportedly exhibited neurological behaviors. Initial reports were from the public and licensed wildlife rehabilitators. Shortly thereafter, additional reports were received in Delaware, New Jersey, Pennsylvania, Ohio, Indiana, Tennessee, and Connecticut (reports were also received in other states but it remains uncertain whether these were related or whether they represented baseline mortality). The majority of the initial reports involved fledgling common grackles (*Quiscalus quiscula*), blue jays (*Cyanocitta cristata*), European starlings (*Sturnus vulgaris*), and American robins (*Turdus migratorius*). Based on a review of state/D.C. data, the majority of reports involved single birds. Substantial media coverage of the event likely encouraged additional public reporting of sick and dead birds, but after additional investigation many jurisdictions found that only a subset of the reports were associated with the event. To date, no human health or domestic animal (livestock, poultry, or companion animal) issues have been documented.

Early in the event, the involved jurisdictions indicated a collective desire to work together in a regional response with consistent public messaging and collaboration among diagnostic laboratories working to identify the cause(s) of the event. This provided an opportunity for the U.S. Geological Survey National Wildlife Health Center (NWHC) to facilitate conversations regarding the event response among the affected jurisdictions and to coordinate with other responding diagnostic laboratories including the University of Georgia Southeastern Cooperative Wildlife Disease Study (SCWDS), the University of Pennsylvania (UPenn) Wildlife Futures Program, and the Indiana Animal Disease Diagnostic Laboratory (IADDL).

The laboratories examined numerous carcasses, tissues, and forage items via necropsy, histopathology, virology, microbiology, parasitology, and toxicology. In addition to traditional techniques, transmitting electron microscopy (TEM) and metagenomics analyses (some laboratory results are still pending) were performed. Despite the exhaustive collective effort of the laboratories, no definitive cause(s) of illness or death have been determined at this time. However, the labs have collectively been able to rule out important diseases and pathogens including salmonellosis, chlamydiosis, avian influenza, West Nile virus, coronaviruses, Newcastle disease, herpesviruses, poxviruses, and *Trichomonas* parasites.

Jurisdiction-based messaging and media interactions during the event focused on ceasing backyard feeding during the event (to reduce the chances for infectious agent transmission at feeding sites), thorough and regular cleaning of feeding/watering devices, sick/dead bird reporting, and appropriate carcass handling and disposal.

A fledgling common grackle (*Quiscalus quiscula*) found in the Washington, D.C. metro region with swollen eyes and crusty discharge, a sign observed in most birds affected by the 2021 mortality event in the area. (Credit: Leslie Frattaroli, National Park Service.)

As of mid-August, reports received by the affected jurisdictions have decreased in many jurisdictions, likely signaling cessation of the event. In response, jurisdictions are modifying, and in many cases completely lifting, their previous guidance to cease feeding but encouraging continued vigilance by those choosing to resume feeding for any indication of illness around their feeders.

DC area passerine morbidity-mortality event, continued

Lessons learned during this event include:

- collaborative regional approaches to disease events are feasible and desirable as they promote common understanding of event status, collective messaging, and inter-laboratory cooperation
- the public is concerned about passerine mortality as evidenced by the number of reports and media attention received for this event
- the public and media can be a useful source for reporting sick/dead birds
- webforms are useful tools to collect information from the public regarding disease events, and well-constructed, automated forms can greatly facilitate agency response while reducing staffing requirements to respond to emails and phone calls

In addition to the cooperating laboratories, we thank the following partner agencies for their involvement and support during this investigation: Connecticut Department of Energy and Environmental Protection, Delaware Department of Natural Resources and Environmental Control, District of Columbia Department of Energy & Environment, Indiana Department of Natural Resources, Kentucky Department of Natural Resources, Maryland Department of Natural Resources, New Jersey Department of Environmental Protection, Ohio Department of Natural Resources, Pennsylvania Game Commission, Tennessee Wildlife Resources Agency, Virginia Department of Wildlife Resources, West Virginia Division of Natural Resources, National Park Service, U.S. Fish and Wildlife Service, and the Smithsonian Institution. For additional information on this event, contact Bryan Richards, brichards@usgs.gov.

WHISPers development update

We have previously reported on the status of the Wildlife Health Information Sharing Partnership – event reporting system (WHISPers) and recent system development efforts (see the 2021 NWHC report to the North American Wildlife and Natural Resources Conference). We are actively working with multiple state, federal, and tribal agency partners to onboard partner agencies into the system. As more partners use the system, WHISPers' capabilities as a collaboration platform for wildlife health professionals will be realized and the system will provide more robust and timely situational awareness regarding wildlife health events, informing response among both the wildlife health and biosurveillance communities. While the current system provides unique partner-based capabilities to manage and serve event data, we continuously seek opportunities to develop additional system capabilities.

Recent wildlife morbidity/mortality events entered into WHISPers by and on behalf of agency partners.

In the recently passed *American Rescue Plan Act of 2021*, Congress provided funding to the U.S. Fish and Wildlife Service (FWS) "… to address wildlife disease outbreaks …" and specifically called for the development of a "national wildlife disease database." FWS plans to work with the U.S. Geological Survey (USGS) and the National Wildlife Health Center (NWHC) to further WHISPers development in order to realize Congress' direction and promote WHISPers as the "National Wildlife Disease Database" called for in the Act.

WHISPers development update, continued

As a result, we have ambitious development plans for WHISPers over the next 5 years that will help meet agency needs, provide an improved user experience, and better inform wildlife health across the landscape. Initially we plan to address system functionality that will vastly improve user experience. The first substantial effort will be system expansion to accommodate active, designed surveillance efforts for specific pathogens or pathogen suites (e.g., HPAI, WNS, SARS-CoV-2, CWD, etc.) in a disease-agnostic fashion so that WHISPers will be able to accommodate and serve data (both individual-level and aggregated) from surveillance efforts, regardless of the pathogen or disease.

Subsequent efforts will enable porting of information from WHISPers to trusted, external systems for analyses, and allow overlay and mining of resulting data layers within WHISPers. We also plan to develop capabilities to import data from multiple trusted external systems for overlay with event records stored within WHISPers. We are additionally contemplating handheld device versions of WHISPers (apps) since agency professionals typically encounter wildlife mortality events while in the field and an application would improve their ability to enter events and request laboratory diagnostic assistance from their cellular phones.

We greatly appreciate the support state, federal, and tribal partners, and the Association of Fish and Wildlife Agencies (AFWA), have provided throughout WHISPers development to date. As with previous system development, we will work closely with agency partners and AFWA to assure that future development is robust, user-friendly, addresses partner needs, better informs wildlife health, and fulfills Congress' direction. To learn more about WHISPers and how to participate please visit https://whispers.usgs.gov/. For more information, contact Bryan Richards, brichards@usgs.gov; Katie Richgels, krichgels@usgs.gov, or WHISPers@usgs.gov.

Preventive actions reduced Bsal risk in the U.S.

The emerging pathogen *Batrachochytrium salamandrivorans* (Bsal) is a severe threat to global urodelan (salamanders, newts, and related taxa) biodiversity. Although Bsal has not been detected in North America, the impacts to urodelan biodiversity could be significant given North America's rich biodiversity of these amphibians. Therefore, U.S. Fish and Wildlife Service (FWS) responded quickly to this emerging threat through a risk-based approach to preventive management actions, including interim regulations on importation of captive salamanders and a large-scale surveillance effort (Richgels et al. 2016; Yap et al. 2015). A new study (Grear et al. 2021) evaluated the impact of these actions and updated the previous Bsal risk assessment to allow for adaptive decision-making on risk reduction.

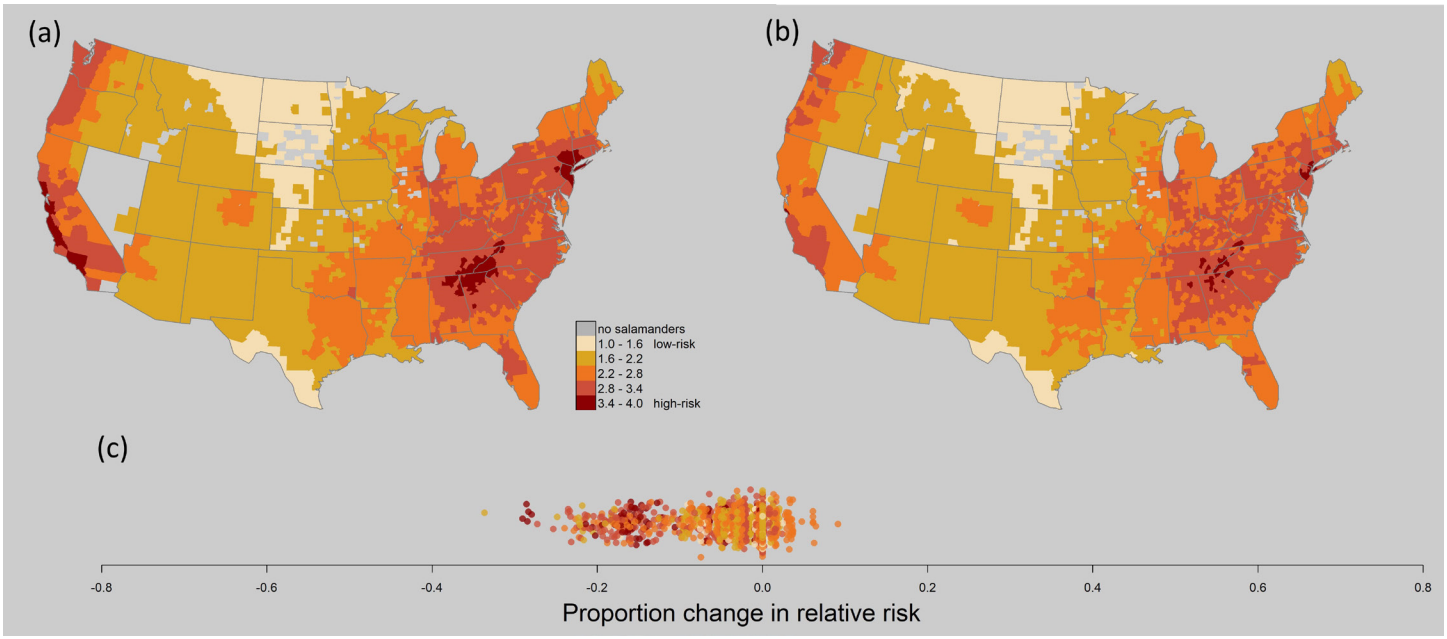
The study found that regulatory actions put in place in 2016 by FWS under in the Lacey Act had the intended effect of reducing salamander imports and subsequent risk of introduction. However, recent research (see literature review in Grear et al. 2021) demonstrated that additional species that are traded globally are also capable of carrying Bsal infection. The lack of knowledge about these additional species limited the overall risk-reduction of the initial regulatory actions.

Widespread surveillance conducted by the U.S. Geological Survey (USGS) Amphibian Research and Monitoring Initiative contributed to reducing consequence risk by increasing confidence of Bsal absence in high-risk areas (Waddle et al. 2020). The authors caution, however, that the risk-reduction benefit of surveillance is restricted to the surveillance time-period; ongoing surveillance will remain important as long as there is continued import and introduction risk.

Ongoing collaboration among the USGS, academic researchers, conservation practitioners, pet industry, and regulatory and management agencies is facilitated by the North American Bsal Task Force to allow exchange of new information and adaptive preventive actions in the face of the Bsal risk. For more information, contact Dan Grear, dgrear@usgs.gov.

Eastern newts (*Notophthalmus viridescens*) are highly susceptible to Bsal. (Credit: Dan Grear, USGS.)

Preventive actions reduced Bsal risk in the U.S., continued



Relative risk maps of combined Bsal risk, comparing (a) pre-action risk (2010–2015), to (b) risk after implementation of surveillance and of importation restrictions on over 200 salamander species. Relative risk scores were scaled to 2010–2015. (c) Change in relative risk score per county as proportion of pre-action risk. Each point is a county, colored by its risk score in (a). From Grear et al. 2021.

Low risk of researchers passing coronavirus to North American bats

A new study (Cook et al. 2021) led by the U.S. Geological Survey (USGS) indicates that the risk is low for scientists to pass coronavirus to North American bats during winter research. In this study, scientists found the overall risk to be 1 in 1,000 if no protective measures are taken, and the risk falls lower, to 1 in 3,333 or less, with proper use of personal protective equipment or if scientists test negative for COVID-19 before beginning research. This study estimated transmission risk to at least one bat during a typical winter survey, which includes a team of five scientists spending one hour in a cave colonized by 1,000 bats. The authors did not examine potential transmission from bats to people.

The study was conducted by the USGS in partnership with the U.S. Fish and Wildlife Service. It focused on the winter season, when wildlife scientists conduct field work that may require close contact with or direct handling of the animals. This includes research on white-nose syndrome and population studies that support Endangered Species Act decisions.

Three bat species – Mexican free-tailed bats (*Tadarida brasiliensis*), little brown bats (*Myotis lucifugus*), and big brown bats (*Eptesicus fuscus*) – were included in the analysis. They were chosen because they have physical and behavioral differences and are typical of the kinds of bats studied in winter. Scientists considered different ways the virus could be transmitted between humans and bats, with airborne transmission as the main pathway.

This research builds on a USGS-led study published in 2020 that examined the likelihood of researchers transmitting SARS-CoV-2 to bats during summer research which can involve different settings and activities than bat research conducted in the winter.

The current assessment represents the best available information and additional research is needed to assess the susceptibility of North American bats, and other species, to new variants of the virus. For more information, contact Jonathan Sleeman, jsleeman@usgs.gov.

USGS wildlife disease specialist collects field samples from a white-nose syndrome positive cave in Vermont. (Credit: USGS.)

SARS-CoV-2 infection trials in North American bats

In spring of 2020, the USGS National Wildlife Health Center (NWHC) conducted an infection trial in big brown bats (*Eptesicus fuscus*) to assess the potential for North American bats to become infected by SARS-CoV-2. Study results indicated that this species is resistant to infection (Hall et al. 2020). To determine the potential susceptibility of other North American bat species, NWHC researchers recently began an experimental challenge trial examining the susceptibility of Mexican free-tailed bats (*Tadarida brasiliensis*) to SARS-CoV-2. This species was selected because it resides in large colonies, often in urban settings, thereby increasing potential risk of exposure to the virus from infected humans. The reservoir potential of these bats for the virus is currently unknown and will be assessed in this study. Study results are expected in the fall of 2021. For more information, contact Jeff Hall, jshall@usgs.gov.

Mexican free-tailed bat (*Tadarida brasiliensis*). (Credit: Ann Froschauer, U.S. Fish and Wildlife Service.)

Systems dynamics approach to evaluate management options for chronic wasting disease

Chronic wasting disease (CWD), a fatal, contagious neurologic disease affecting cervid populations that is increasing in intensity and spatial extent, has proven extremely difficult to manage despite intensive control efforts spanning several decades. CWD is a significant management challenge in part because the etiological agent, an infectious prion, is extremely difficult to destroy and can be transmitted directly or indirectly. The majority of management interventions to date require altering host densities which is not universally supported by stakeholders. To successfully manage CWD, management agencies need approaches that account for the diverse socioeconomic and political pressures surrounding management of white-tailed deer (*Odocoileus virginianus*) and other wild cervid species.

The U.S. Geological Survey National Wildlife Health Center, in collaboration with the Wisconsin Department of Natural Resources (WDNR) and Ventana Systems, Inc., recently initiated a project that will use a systems approach to dynamically map the complex relationships among biological, social, and political processes for CWD. Through participatory modeling we will involve stakeholder groups and experts in CWD, social science, and deer and forest health to integrate the wealth of existing knowledge into a system map that describes its functioning and linkages between ecological and social processes. The final model will be captured in a "management flight simulator" interface that will allow managers to assess the ecological and social consequences of key management alternatives identified during the mapping process, characterize key uncertainties, determine the optimal management strategies, and directly inform the WDNR's CWD planning efforts.

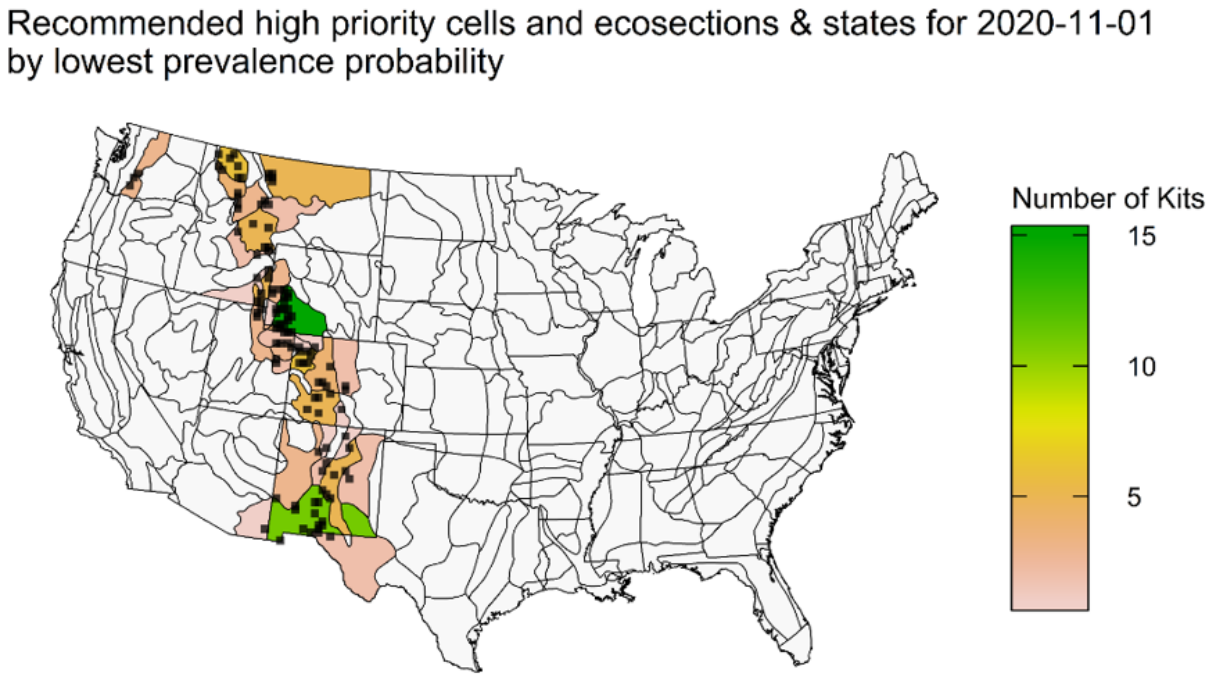
For more information, contact Dan Walsh, dwalsh@usgs.gov or Tami Ryan, tamara.ryan@wisconsin.gov.

White-tailed deer (*Odocoileus virginianus*) in prairie grass. (Credit: Bryan Richards, USGS.)

National white-nose syndrome/*P. destructans* surveillance

For the second consecutive year, the *Pseudogymnoascus destructans* (Pd) national surveillance efforts used a model-based approach, which leverages historical Pd surveillance information maintained at the U.S. Geological Survey National Wildlife Health Center and a dynamic ecological diffusion model that identifies high risk areas where Pd is predicted to emerge each year in western and southern states. The benefits of using this data-driven, model-guided approach, compared to previous years, include improved surveillance efficiency by focusing limited resource allocation to predicted areas at high risk for Pd emergence and reduced time needed to find new hotspots of Pd on the landscape. The approach also allows for quantitative analyses of Pd growth and spread at a landscape scale.

Samples were evaluated from over 200 locations in 25 states during the 2020/21 season and included 1,163 environmental samples and 2,110 bats samples from 25 species. The fungus was detected at 27 sites, including 10 new counties and 2 new states. Passive surveillance, consisting of opportunistic reports of sick or dead bats by the general public, resulted in Pd detections for 9 of these sites, with active surveillance efforts (sampling sites selected according to the diffusion model) resulting in detections at the remaining 16 sites. Montana (Fallon, Carter counties) and Wyoming (Crook County) were the newest states to report their first confirmed cases of the disease after initially detecting the presence of the causative fungus in their states in Spring 2020 and 2019, respectively. WNS was also confirmed for the first time this winter in the Texas panhandle region (Hardeman, Cottle counties) after affecting 18 south-central Texas counties last year. Additionally, clinical signs suggestive of WNS were observed on live cave bats (*Myotis velifer*) at one hibernaculum (De Baca County, NM) and Pd was detected on bats and in environmental samples at this and another hibernaculum (Lincoln County, NM) for the first time in New Mexico, however, no samples were available for histopathological evaluation to confirm disease at either of these locations. Further progression of the disease was also detected this season in Nebraska (Cherry County), and Washington (Chelan County) while Pd range expansion in the absence of clinical disease was noted in Georgia (Muscogee County) and additional counties in Montana (Garfield County), Mississippi (Montgomery County), and Texas (Presidio and Terrell counties). The number of states with confirmed cases of WNS is now 37 with at least 12 species of North American bats known to be susceptible. The disease has yet to be confirmed in California, Mississippi, and New Mexico where the fungus has been reported. For more information, contact Anne Ballmann, aballmann@usgs.gov.



Priority white-nose syndrome/Pd surveillance regions and surveillance kit allocations for the 2020-2021 surveillance season as identified by the Pd Strategic Surveillance Model.

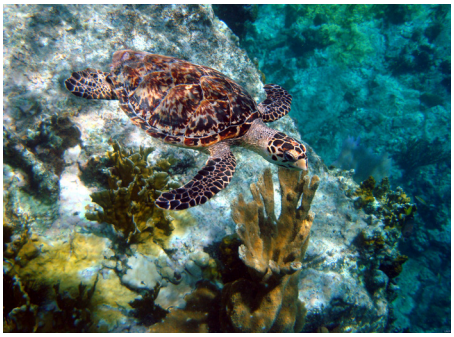
Snake fungal disease research updates

Ophidiomycosis (also called snake fungal disease) has been found in wild snake populations across the eastern half of the U.S. The disease first gained attention in 2008, but whether the causative fungus, *Ophidiomyces ophidiicola*, was introduced to North America around that time was previously not known. The U.S. Geological Survey National Wildlife Health Center (NWHC) and collaborators recently screened historic snake specimens in museum collections and confirmed that ophidiomycosis has been present in wild snakes in the U.S. since at least 1945 (Lorch et al. 2021). Additional work is ongoing to determine if *O. ophidiicola* has been present even longer and thus may be native to North America. The NWHC also recently conducted research to determine if the fungus can persist in the environment. The results of that study suggested that *O. ophidiicola* is common in the soil of snake hibernacula and can persist in a viable state in the environment in the absence of snake hosts (Campbell et al. 2021). These findings indicate that communal hibernation sites may serve an important role in disease transmission of ophidiomycosis. For more information, contact Jeff Lorch, jlorch@usgs.gov.

Plain-bellied water snakes (*Nerodia erythrogaster*) found at the same location in Louisiana. On the left a healthy snake and on the right a snake afflicted with lesions consistent with snake fungal disease. (Credit: Brad 'Bones' Glorioso, USGS.)

Sea turtles across the North Pacific are exposed to perfluoroalkyl substances

Perfluorinated alkyl substances (PFASs) are global, persistent, and toxic contaminants found in food packaging and some food products. A joint study between the National Institute of Standards and Technology, National Oceanic and Atmospheric Administration, and U.S. Geological Survey examined exposure of green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles from the North Pacific and found 15 PFAS compounds in blood and eggs. Concentrations were greater in hawksbill than green turtle plasma likely due to trophic level differences (hawksbill turtles are carnivores and green turtles are herbivores). There was no relationship between the tumor disease fibropapillomatosis and exposure to PFAS; however, hawksbill eggs from locations near airports had higher levels than those away from airports and levels correlated with reduced nest emergence success. PFAS substances have been shown to have harmful effects on other wildlife species and the finding of these chemicals in sea turtles suggests a need to better understand impacts of these chemicals on marine reptiles. For more information, contact Thierry Work, thierry_work@usgs.gov.



An endangered hawksbill (*Eretmochelys imbricata*) swimming over a colony of elkhorn coral (*Acropora palmata*). (Credit: Caroline Rogers, USGS.)

Update from the World Organisation for Animal Health (OIE)

The OIE has recently released a series of wildlife disease technical cards. The technical cards contain information on several wildlife diseases including etiology, epidemiology, diagnosis, prevention and control, and potential impacts of the disease agent. The cards provide guidance on case and disease definition and facilitate reporting of these wildlife diseases to the OIE and are available at https://www.oie.int/en/what-we-do/animal-health-and-welfare/animal-diseases/technical-disease-cards/

The OIE has also recently approved a Wildlife Health Framework. The

Update from the World Organisation for Animal Health (OIE), continued

Framework provides a set of wildlife-related objectives that the OIE will work towards by integrating wildlife health into all areas of its activities. These wildlife-related objectives are designed to ensure that OIE Members are supported in improving:

1. their ability to reduce, anticipate, and manage the risk of pathogen emergence and transmission at the human–animal–ecosystem interface;
2. early detection, notification, and management of wildlife diseases.

The Wildlife Health Framework is available online: https://www.oie.int/fileadmin/Home/eng/Internationa_Standard_Setting/docs/pdf/WGWildlife/A_Wildlifehealth_conceptnote.pdf

For more information, contact Jonathan Sleeman (jsleeman@usgs.gov), OIE National Focal Point for Wildlife for the United States.

Recent NWHC publications

Aeby GS, Shore A, Jensen T, Ziegler M, Work T, Voolstra CR, 2021. A comparative baseline of coral disease in three regions along the Saudi Arabian coast of the central Red Sea. PLOS ONE 16(7): e0246854. https://doi.org/10.1371/journal.pone.0246854

Andersson ER, Day RD, Work TM, Anderson PE, Woodley CM, Schock TB, 2021. Identifying metabolic alterations associated with coral growth anomalies using 1H NMR metabolomics. Coral Reefs 40, 1195-1209. https://doi.org/10.1007/s00338-021-02125-7

Apprill A, Holm H, Santoro AE, Becker C, Neave M, Hughen K, Donà AR, Aeby G, Work TM, Weber L, McNally S, 2021. Microbial ecology of coral-dominated reefs in the Federated States of Micronesia. Aquatic Microbial Ecology 86, 115-136. https://doi.org/10.3354/ame01961

Campbell LJ, Burger J, Zappalorti RT, Bunnell JF, Winzeler ME, Taylor DR, Lorch JM, 2021. Soil reservoir dynamics of *Ophidiomyces ophidiicola*, the causative agent of snake fungal disease. Journal of Fungi 7. https://doi.org/10.3390/jof7060461

Cook JD, Campbell Grant EH, Coleman JTH, Sleeman JM, Runge MC, 2021. Risks posed by SARS-CoV-2 to North American bats during winter fieldwork. Conservation Science and Practice 3. https://doi.org/10.1111/csp2.410

Deng K, Uhlig S, Ip HS, Killian ML, Goodman LB, Nemser S, Ulaszek J, Pickens S, Newkirk R, Kmet M, Frost K, Hettwer K, Colson B, Nichani K, Schlierf A, Tkachenko A, Reddy R, Reimshuessel R, 2021. Interlaboratory comparison of SARS-CoV2 molecular detection assays in use by U.S. veterinary diagnostic laboratories. Journal of Veterinary Diagnostic Investigation, https://doi.org/10.1177/10406387211029913

Falendysz EA, Calhoun DM, Smith CA, Sleeman, JM, 2021. Outside the box: Working with wildlife in biocontainment. ILAR Journal. https://doi.org/10.1093/ilar/ilab025

Gibble C, Kudela R, Knowles S, Bodenstein B, Lefebvre K, 2021. Domoic acid and saxitoxin in seabirds in the United States between 2007 and 2018. Harmful Algae 103. https://doi.org/10.1016/j.hal.2021.101981

Grear DA, Mosher BA, Richgels K, Campbell Grant EH, 2021. Evaluation of regulatory action and surveillance as preventive risk-mitigation to an emerging global amphibian pathogen *Batrachochytrium salamandrivorans* (Bsal). Biological Conservation 260. https://doi.org/10.1016/j.biocon.2021.109222

Hall JS, Grear DA, Krauss S, Seiler P, Dusek RJ, Nashold S, Webster RG, 2021. Highly pathogenic avian influenza virus H5N2 (Clade 2.3.4.4) challenge of mallards age appropriate to the 2015 midwestern poultry outbreak. Influenza and Other Respiratory Viruses. https://doi.org/10.1111/irv.12886

Keatts L, Robards MD, Olson SH, Hueffer K, Insley S, Joly DO, Kutz S, Lee DS, Chetkiewicz C-LB, Lair S, Preston ND, Pruvot M, Ray JC, Reid D, Sleeman JM, Stimmelmayr R, Stephen C, Walzer C, 2021. Implications of zoonoses from hunting and use of wildlife in North American arctic and boreal biomes: Pandemic potential, monitoring, and mitigation. Frontiers in Public Health 9. https://doi.org/10.3389/fpubh.2021.627654

Lankton JS, Knowles S, Keller S, Shearn-Bochsler VI, Ip HS, 2021. Pathology of *Lagovirus europaeus* GI.2/RHDV2/b (rabbit

Recent NWHC publications, continued

hemorrhagic disease virus 2) in native North American lagomorphs. Journal of Wildlife Diseases 57, 694-700. https://doi.org/10.7589/JWD-D-20-00207

Lorch JM, Price SJ, Lankton JS, Drayer AN, 2021. Confirmed cases of Ophidiomycosis in museum specimens from the USA as early as 1945. Emerging Infectious Diseases 27, 1986-1989. https://doi.org/10.3201/eid2707.204864

McCaffery R, Russell RE, Hossack BR, 2021. Enigmatic near-extirpation in a boreal toad metapopulation in northwestern Montana. Journal of Wildlife Management 85, 953-963. https://doi.org/10.1002/jwmg.22054

Rhynd KJR, Walsh DP, Arthur-Banfield LCM, 2021. Efficacy of fenbendazole and ivermectin against *Trichuris* spp. in African green monkeys (*Chlorocebus sabaeus*) in Barbados West Indies. Journal of the American Association for Laboratory Animal Science 60(4):475-483. https://doi.org/10.30802/aalas-jaalas-20-000103

Rogers K, Mete A, Ip HS, Torchetti MK, Killian ML, Crossley B, 2021. Emergence and molecular characterization of pigeon Paramyxovirus-1 in non-native Eurasian collared doves (*Streptopelia decaocto*) in California, USA. Infection, Genetics and Evolution 91. https://doi.org/10.1016/j.meegid.2021.104809

Vanderwolf KJ, Campbell LJ, Taylor DR, Goldberg TL, Blehert DS, 2021. Mycobiome traits associated with disease tolerance predict many western North American bat species will be susceptible to white-nose syndrome. Microbiology Spectrum. https://doi.org/10.1128/Spectrum.00254-21

Walker N, Hefley TJ, Ballmann A, Russell RE, Walsh DP, 2021. Recovering individual-level spatial inference from aggregated binary data. Spatial Statistics 44. https://doi.org/10.1016/j.spasta.2021.100514

Wood C, Balazs GH, Rice M, Work TM, Jones TT, Sterling EJ, Summers TM, Brooker J, Kurpita L, King CS, Lynch JM, 2021. Sea turtles across the North Pacific are exposed to perfluoroalkyl substances. Environmental Pollution 279. https://doi.org/10.1016/j.envpol.2021.116875

Work TM, Weatherby TM, DeRito CM, Besemer RM, Hewson I, 2021. Sea star wasting disease pathology in *Pisaster ochraceus* shows a basal-to-surface process affecting color phenotypes differently. Diseases of Aquatic Organisms 145, 21-33. https://doi.org/10.3354/dao03598

More Information from the NWHC

Visit our website at www.usgs.gov/nwhc and follow us on Twitter @USGSWILDLIFE
To sign up to receive Newsletters and Wildlife Health Bulletins from the NWHC, please visit https://listserv.usgs.gov/mailman/listinfo/usgs-nwhc_outreach or email nwhcoutreachdb@usgs.gov.